The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed J.E. Evans.

Dated 7 September 2001

Patents Form 1/77

Patents Act 1977

1-1 SEP 2000

The Patent Office

THE PATENT OFFICE
J
- 1 SEP 2000
NEWPORT

01SEP00 E564918-1 D00393
P01/7700 0.00-0021374.4

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
Gwent NP9 1RH

1. Your reference

2000P04847/GB/R76/MM/rr

2. Patent application number
(The Patent Office will fill in this part)

0021374.4

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

ROKE MANOR RESEARCH LIMITED

OLD SALISBURY LANE
ROMSEY
HAMPSHIRE, SO51 0ZN
UNITED KINGDOM

Patents ADP number *(if you know it)*

8615455006

If the applicant is a corporate body, give the country/state of its incorporation

UNITED KINGDOM

4. Title of the invention

IMPROVEMENTS IN OR RELATING TO LEAK DETECTION SYSTEMS

5. Name of your agent *(if you have one)*

DEREK ALLEN

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Siemens Shared Services Limited
Intellectual Property Department
Siemens House, Oldbury
Bracknell, Berkshire RG12 8FZ
United Kingdom

Patents ADP number *(if you know it)*

7761006002

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

YES

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	10
Claim(s)	3
Abstract	1
Drawing(s)	1

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	1
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature M D Mackett Date 31.08.2000

Margaret Mackett

12. Name and daytime telephone number of person to contact in the United Kingdom — Margaret Mackett — 01344 396808

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*

d) *If you have answered 'Yes' Patents Form 7/77 will need to be filed.*

e) *Once you have filled in the form you must remember to sign and date it.*

f) *For details of the fee and ways to pay please contact the Patent Office.*

Patents Form 7/77

Act 1977
(Rule 15)

1-1 SEP 2000

The Patent Office

7/77

Statement of inventorship and of right to grant of a patent

THE PATENT OFFICE
J
- 1 SEP 2000
NEWPORT

The Patent Office

Cardiff Road
Newport
Gwent NP9 1RH

1. Your reference

2000P04847/GB/R76/MM/rr

2. Patent application number
(If you, know it)

0021374.4

3. Full name of the or of each applicant

ROKE MANOR RESEARCH LIMITED

4. Title of the invention

IMPROVEMENTS IN OR RELATING TO LEAK DETECTION SYSTEMS

5. State how the applicant(s) derived the right from the inventor(s) to be granted a patent

By provisions of contract of service and Section 39(1) (a) and (b) of the Patent Act 1977.

6. How many, if any, additional Patents Forms *7/77* are attached to this form?
(see note (c))

ONE

I/We believe that the person(s) named over the page (*and on any extra copies of this form)* is/are the inventor(s) of the invention which the above patent application relates to.

Signature M Mackett Date 31.08.2000

Margaret Mackett

8. Name and daytime telephone number of person to contact in the United Kingdom

Margaret Mackett 01344 396808

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If 'there are more than three inventors, please give the names and addresses of the other inventors on the back of another Patents Form 7/77 and attach it to this form.*

d) *When an application does not declare any priority, or declares priority from an earlier UK application, you must provide enough copies of this form so that the Patent Office can send one to each inventor who is not an applicant.*

e) *Once you have filled in the form you must remember to sign and date it.*

Enter the full names, addresses and postcodes of the inventors in the boxes and underline the surnames

JOYNES George Malcolm Swift
Illetas Cottage
Pine Walk
SOUTHAMPTON
Hampshire
SO16 7HJ

Patents ADP number *(if you know it)*: 120733002

Patents ADP number *(if you know it)*:

Patents ADP number *(if you know it)*:

Reminder

Have you signed the form?

IMPROVEMENTS IN OR RELATING TO LEAK DETECTION SYSTEMS

The present invention relates to improvements in or relating to leak detection systems.

In domestic situations, the plumbing system is usually quite reliable. However, in terms of functionality and freedom from leakages or overflows, even a single leak within the confines of the house can be extremely expensive and disruptive to those living there. One example of the risks to which most people are exposed is that washing machines are usually permanently connected to the water mains system, and virtually no-one turns off the taps which may be provided on the mains/hot water pipes leading to the machine between periods of use. Whether the machine is working or not, it may be the case that no-one is in its vicinity or even in the house. While many people may not have personally experienced a major leakage, such as a failure of the joints to the flexible pipes that lead to the machine, they would be able to say they knew of relatives or friends to whom this had once occurred. Awareness of the threat is therefore likely to be fairly high in the public mind, and so means to avert such problems could be attractive.

Another example of the risks is flooding caused by burst pipes in the loft or attic which are connected to a cold water tank. It will be appreciated that this scenario has greater potential for damage than leakage at a washing machine.

In addition to the above, the advent of water metering has made the inadvertent wastage of water of greater importance to the home-owner (and

also to the water companies, who wish to foster the more responsible and economical use of what is now a far from abundant resource in some areas or times of the year).

It is therefore an object of the present invention to provide a novel system for detecting the presence of leaks in premises of a water consumer and for alerting someone at the premises in which such a system is fitted to the presence of such leaks. The system may be used either in domestic premises or elsewhere.

In accordance with one aspect of the present invention, there is provided a leakage detection system for connection to a fluid carrying system, the detection system comprising:-

at least one sensor attached to the fluid carrying system for measuring data for the fluid at the point of attachment and for providing output signals indicative of data relating to at least one characteristic of the fluid;

data transfer means for transmitting the output signals from each sensor; and

a processing unit for receiving signals from the data transfer means and for comparing the measured data with reference data to determine the presence of a leakage.

Advantageously, each sensor comprises a vibration sensor for measuring vibration in the fluid carrying system. The vibration sensor may include a piezo-electric material. Alternatively, the vibration sensor includes a PVDF film material.

Preferably, each sensor includes amplifier means and/or electronic matching means for amplifying the output signals indicative of data

relating to at least one characteristic of the fluid prior to transfer to the data transfer means.

The leak detection system may further comprise a power supply for supplying power to the sensor. The power supply may comprise a battery pack or a mains electricity supply.

The data transfer means may comprise a radio communications link between each sensor and the processing unit. Alternatively, the data transfer means may comprise a wired connection between each sensor and the processing unit. In another arrangement, the data transfer means may comprise a mains supply electricity system connecting each sensor to the processing unit.

The processing means may comprise a microcomputer.

In accordance with the present invention, emphasis is made on providing equipment and a system which are inexpensive and can be installed by a reasonably competent DIY person, although application may also be found in professionally installed systems as well. As well as private houses, hotels and other commercial premises may well benefit from the introduction of this detection and alerting system.

The basis of the system is the combining of simple flow sensors in an architecture which enables the outputs of the one or more sensors to be combined to give a reasonably high probability that a leak has occurred – rather than merely an indication of a temporary change in flow rates in the various pipes in the plumbing system. The latter will often occur as water is drawn by the occupants and is used to replenish cisterns, etc. If there is only one flow sensor in the system, the only way to deduce whether or not there is a problem is to wait long enough for the water flows to stop, or at

least for it to be evident that an anomalous situation has arisen. This wait may mean that a warning of the leak or burst is not given early enough.

For a better understanding of the present invention, reference will now be made, by way of example only, to the accompanying drawings in which:-

Figure 1 is a schematic arrangement of a house with a system in accordance with the present invention; and

Figure 2 illustrates a flow sensor for used in the system shown in Figure 1.

Although the present invention will be described with reference to a domestic plumbing system for a house, it will be appreciated that it also has application in plumbing systems for offices, hotels, flats and apartments etc.

Referring initially to Figure 1, an exemplary domestic plumbing system 10 is shown. The plumbing system 10 comprises a cold water tank 12, a hot water tank 14, a bathroom 16, a cloakroom 18, a washing machine 20, and an outside tap 22 which are connected together by lengths of pipe indicated generally by reference numerals 28, 30, 32, 34, 36, 38, 40, 42. Although not shown in the plumbing system 10, it will readily be appreciated that sinks located in kitchens and utility rooms as well as dishwashers could also be included in such a plumbing system.

The cold water tank 12 is typically located in a loft or attic of the house and has the potential to cause substantial damage if there is a leakage associated with it. The cold water tank 12 is connected directly to the mains supply 24 via stopcock 26 and pipe 28.

The hot water tank 14 and the bathroom 16 are typically located on an upper floor of the house, the hot water tank 14 being located in an airing cupboard (not shown) which may be located within the bathroom 16, in another room or on the landing. The hot water tank 14 is connected to receive cold water from the cold water tank 12 via pipes 32, 36 and to provide an overflow into the cold water tank 12 via pipe 42. It will readily be appreciated that the hot water tank 14 is connected by pipe (not shown) to supply hot water to the bathroom 16, the cloakroom 18 and the washing machine 20 as well as other sinks, baths or showers (not shown) which may be present in the house.

The cloakroom 18 is typically located on a lower floor of the house as is the washing machine 20. The outside tap 22 is located on a wall externally to the house. In the illustrated system, the cloakroom 18 is connected to the mains supply 24 via stopcock 26 via pipe 30 with the washing machine 20 and outside tap 22 connected in series with the cloakroom 18 by means of pipes 38, 40 as shown.

In accordance with the present invention, the system 10 also includes a plurality of flow sensor units 44, 46, 48, 50, 52, 54, 56, 58 connected to sense flow of water in the pipes 28, 30, 32, 34, 36, 38, 40. It will be noted that the sensor units are located on each pipe so as to be associated with possible sources of leakage.

Each flow sensor unit 44, 46, 48, 50, 52, 54, 56, 58 is clipped onto its associated length of pipe 28, 30, 32, 34, 36, 38, 40 and its associated cable 60 is connected to a processing unit (not shown) as shown in Figure 2. Only flow sensor unit 44 on pipe 28 is shown for simplicity, but each of the other sensors will be arranged in the same way on their associated

length of pipe with their associated cable connected to the processing unit (not shown).

The flow sensor units 44, 46, 48, 50, 52, 54, 56, 58 are attached to the pipes 28, 30, 32, 34, 36, 38, 40 in the plumbing system 10 in such a way that flow of water along each part thereof is monitored. As mentioned above, the use of a single, inexpensive sensor unit can be considered also, although its benefit will be less as it will be more difficult to pinpoint the source of a leakage.

As will readily be appreciated, the flow sensor units 44, 46, 48, 50, 52, 54, 56, 58 and the processing unit (not shown) comprise a sensing system in accordance with the present invention. Ideally, each flow sensor unit 44, 46, 48, 50, 52, 54, 56, 58 is a relatively simple device to reduce the overall cost of implementing the system. By using a simple flow sensor unit or flow meter, the demands on the rest of the sensing system become somewhat greater, to balance out the deficiencies of the flow sensor unit. However, this can be done by the use of electronics and signal processing, thereby providing an inexpensive system.

A method of determining the presence of a leakage using a simple flow sensor unit is described in co-pending British patent application no. _____ entitled "Improvements in or Relating to Fluid Flow Sensors" (Our reference 2000P04846) filed concurrently herewith. Such a method can be extended to the system of the present invention. A key requirement is to provide a sensor that can be easily mounted onto the water pipe or fitting, rather than be inserted in the pipe. Thus, the concept of a 'clip on' sensor is paramount.

A domestic plumbing system consists of several lengths of pipe joined together, and connecting various control devices, cisterns and output orifices as described above with reference to Figure 1. Water flows into the system through one inlet pipe 24, and flows out via several outlets 12, 14, 16, 18, 20. Any outflow from the plumbing system must be produced either by an equal inflow in the inlet pipe 24 or from some cistern. For a part of the system with no cistern, measuring the flow through the inlet pipe 24 will detect any outflow, whether it be normal usage or a leak.

The mains water supply 24 comes into the house and passes through the inside stopcock 26 as shown in Figure 1. It immediately passes through the pipe 28 that has sensor 44 which determines the amount of flow coming from the mains supply 24 into the house, but not which part of the house it is being used in. A single sensor at this point may be satisfactory in a simple situation. So, this would be acceptable if the objective were to protect the house against the risk of leakage or flooding, if the measurement could be made when one was certain that no water was being drawn deliberately or cistern being filled.

One enhancement of the system is to install the sensor 58 just inside the house at the other side, in the pipe 40 which leads out to the garden tap 22. In this way, if tap 22 is inadvertently left running or freezing conditions have resulted in the pipe 40 bursting, a more directed alerting to possible problems in the plumbing is available.

A further addition is to include sensor 54 in pipe 30. This will enable the system to determine differences between the flow to the outside tap 22 on the ground floor, what flows to the downstairs equipment (e.g. cloakroom 18) and what is flowing to the first floor. Again, with some

simple logical and measurement capability, localisation of the water demand or leakage can be quickly made.

A potential source of considerable risk is the washing machine 20 as described above. Thus, sensor 56 is shown connected close to the machine 20, preferably on the spur that comes from the pipe 38.

For the upstairs, further flow sensors may be used. Sensor 46 determines the flow into the cold water tank 12, which should not demand water for long periods unless either a pipe leading from it is demanding water, or the tank is overflowing for some reason, such as a failing ballcock (not shown).

Sensor 48 can be used to compare the input to the cold water tank 12 with the demand from the pipes 32, 34, 36 connected to it.

Of the pipes connected to the cold water tank 12, sensors 50 and 52 can be used to determine the flows to the upstairs hot water tank 14, and basins and lavatories, for example, bathroom 16. [The hot water system is not included in this simple description of the alerting system.]

In accordance with a system of the present invention, each sensor is connected to transmit sensor data to a processing unit (not shown) which is located in a central position (possibly by the front door). The processing unit makes comparisons between sensor data and various input data that describes the likely or expected states of flow, perhaps with reference to time of day, or whether the occupants are on holiday, at work or at home. Outputs from the sensors may be communicated to the processing unit in several ways, for example:-

- using a radio technique such as 'Bluetooth';

- using a mains wiring system;
- using an ultrasonic technique along the pipes;
- making use of some already-installed system, such as a security system;
- using an in-air ultrasonic communications; or
- using an inductive loop system.

However, the choice of the means of communication between each sensor and the processing unit will depend on factors such as:-

- battery life if the sensors can be powered by battery;
- the permanence of the installation;
- the requirement for additional wiring; and
- the use of the pipes or the house electric wiring for conveying the sensor data to the processing unit.

As described in our co-pending application discussed above, the sensor unit may include a pre-amplifier/buffer unit for amplifying the sensor output signals for transmission to the processing unit. Powering of the sensor and pre-amplifier/buffer unit can be by battery as described in our co-pending application discussed above, by connection to a mains power supply, or perhaps by a remote powering technique, whereby electromagnetic, hydraulic, thermal or acoustic energy is coupled into a power converter, thereby providing sufficient power for the circuits.

If the processing unit determines that the presence and, ideally, the location of a leakage, this information is used to alert a consumer that there is a problem. This information could be used locally, or in the future considered for connecting to a micro-web server, so that it could be made

available to relatives, neighbours, the local police or other interested/responsible parties.

It is also envisaged that the system in accordance with the present invention could interact with domestic appliances which may be the cause of leakages, for example, washing machines and dishwashers. The sensor unit associated with such appliances could be powered from the mains and could be capable of determining whether the appliance is in use or not.

One way for implementing this is to include an adapter which fits into a standard electrical socket and into which the plug of the appliance is inserted. The adapter may include a pre-amplifier/buffer unit for connection to the sensor via a short length of wire, the sensor being located on adjacent pipe.

It will be appreciated that this could provide an intelligent system which can determine if the sensor data received by the processing unit is due to use of the appliance or to due to a leakage.

The processing unit comprises a simple computer system which can accommodate or allow for shortfalls in the sensor units due to their relative cheapness.

The processing unit may include a display panel which indicates whether each sensor is working correctly and whether the data being received at the processing unit relates to a leakage or to standard operation of the pipes to which the sensors are attached.

Although the present invention has been described with reference to water systems, it will be appreciated that it is equally applicable to systems carrying other types of fluids.

CLAIMS:

1. A leakage detection system for connection to a fluid carrying system, the detection system comprising:-

at least one sensor attached to the fluid carrying system for measuring data for the fluid at the point of attachment and for providing output signals indicative of data relating to at least one characteristic of the fluid;

data transfer means for transmitting the output signals from each sensor; and

a processing unit for receiving signals from the data transfer means and for comparing the measured data with reference data to determine the presence of a leakage.

2. A leak detection system according to claim 1, wherein each sensor comprises a vibration sensor for measuring vibration in the fluid carrying system.

3. A leak detection system according to claim 2, wherein the vibration sensor includes a piezo-electric material.

4. A leak detection system according to claim 2, wherein the vibration sensor includes a PVDF film material.

5. A leak detection system according to claim 2, wherein the vibration sensor comprises a strain gauge or geophone.

6. A leak detection system according to any one of the preceding claims, wherein each sensor includes amplifier means and/or electronic matching means for amplifying the output signals indicative of data relating to at least one characteristic of the fluid prior to transfer to the data transfer means.

7. A leak detection system according to any one of the preceding claims, further comprising a power supply for supplying power to the sensor.

8. A leak detection system according to claim 7, wherein the power supply comprises a battery pack.

9. A leak detection system according to claim 7, wherein the power supply comprises a mains electricity supply.

10. A leak detection system according to claim 7, wherein the power supply is provided by a remote powering technique.

11. A leak detection system according to claim 10, wherein the remote powering technique comprises coupling electromagnetic, hydraulic, thermal or acoustic energy into a power converter to provide the power supply.

12. A leak detection system according to any one of the preceding claims, wherein the data transfer means comprises a radio communications link between each sensor and the processing unit.

13. A leak detection system according to any one of claims 1 to 11, wherein the data transfer means comprises a wired connection between each sensor and the processing unit.

14. A leak detection system according to any one of claims 1 to 11, wherein the data transfer means comprises a mains supply electricity system connecting each sensor to the processing unit.

15. A leak detection system according to any one of the preceding claims, wherein the processing means comprises a microcomputer.

15. A leak detection system substantially as hereinbefore described with reference to the accompanying drawings.

ABSTRACT

IMPROVEMENTS IN OR RELATING TO LEAKAGE DETECTION SYSTEMS

Described herein is a leakage detection system for use with a domestic plumbing system (10). The leakage detection system comprises a plurality of sensors (44, 46, 48, 50, 52, 54, 56, 58) which are located on pipes (28, 30, 32, 34, 36, 38, 40) in the plumbing system (10) adjacent points where there is a possibility of leakage, for example, adjacent a washing machine (20). The sensors (44, 46, 48, 50, 52, 54, 56, 58) monitor flow characteristics of the plumbing system (10) and pass information relating to those characteristics to a processing unit where comparisons are carried out to determine if leakage is present, and if so, where it is in the system (10).

(Fig. 1)

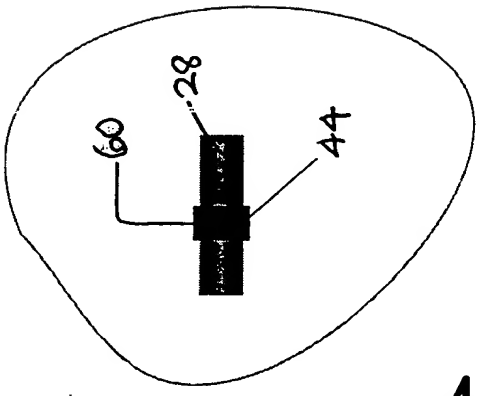
60
28
44

Fig. 2

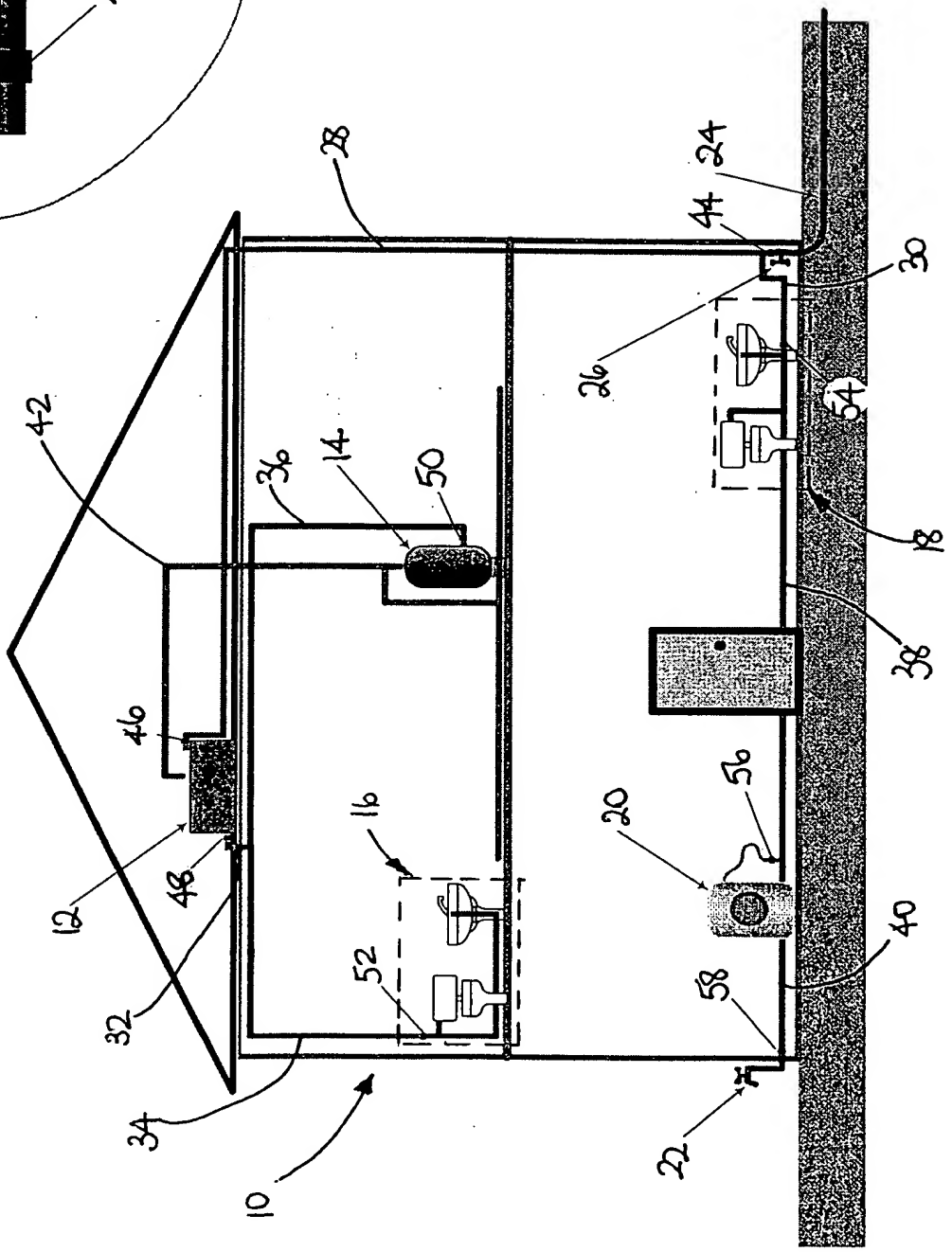
28
24
44
30
26
54
42
36
14
50
18
38
46
12
48
16
20
56
32
52
40
58
34
10
22

Fig. 1